Idaho National Engineering and Environmental Laboratory

Fast Neutron Flux Booster in the Advanced Test Reactor

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Advanced Nuclear Fuel Cycle Program
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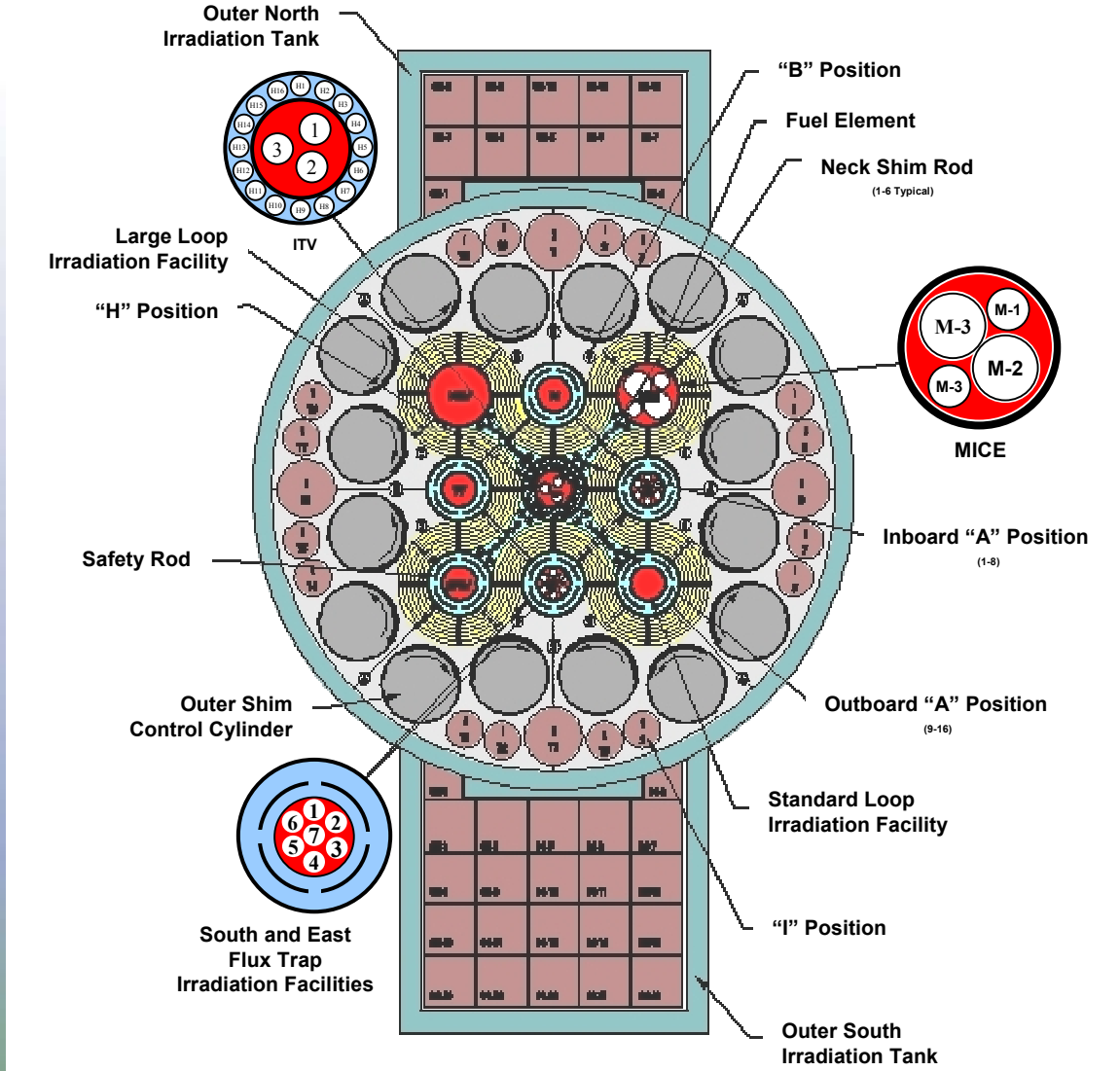
An FFB is Needed to Support AFCI Fuels Testing

- *The hard neutron spectrum in fast reactors provides an efficient way to transmute and burn up transuranic actinides*
- *The US does not have an operating fast reactor*
- *An FFB can be installed in the Advanced Test Reactor (ATR) to provide a flux environment representative of the fast flux spectrum in a fast reactor*

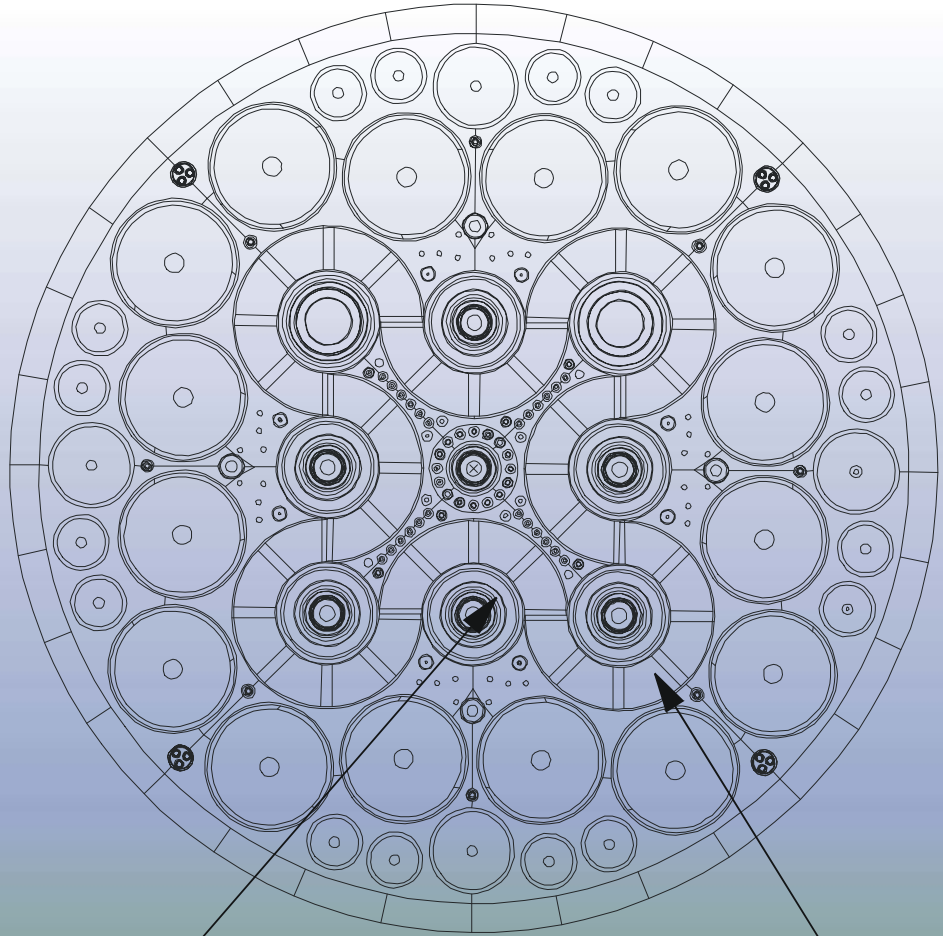
Previous Experience in the ATR Points to a Successful Outcome

- *An FFB using an active fuel booster was designed, fabricated, installed, and operated in the ATR (I-11 position)*
- *The booster was used on a material irradiation program conducted for the Japanese from 1997-2002*
- *The test facility was made up of a fuel ring with 4 three-plate elements with high-enriched uranium*
- *This test facility produced a factor of 3.3 increase in the fast flux*

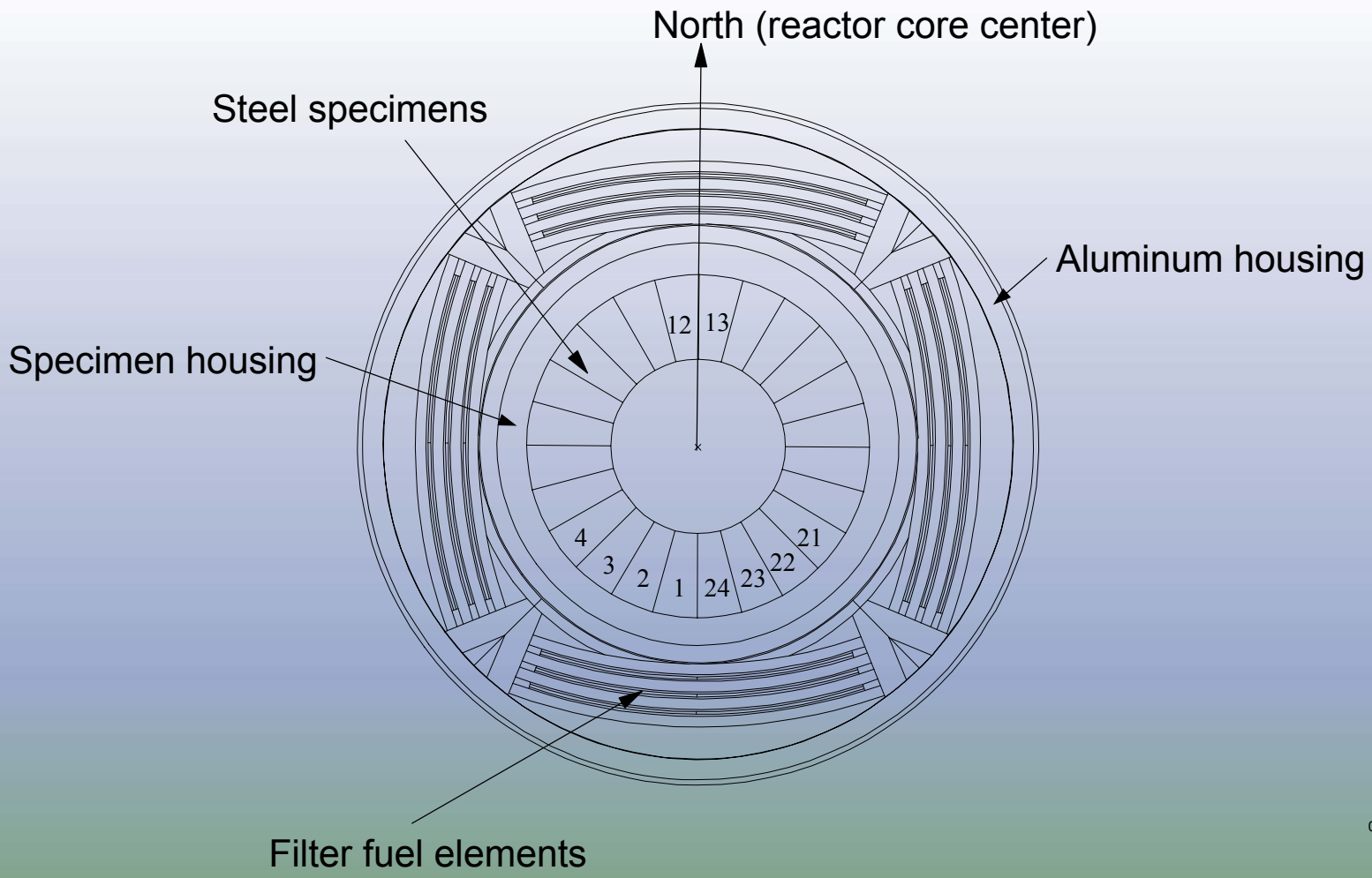
ATR Core Cross Section



Plan View of the Full Core MCNP Model of the Advanced Test Reactor



Irradiation Vehicle Placed in the Large I-11 Position of the ATR



FFB Objectives

- *An FFB will be designed and installed in an existing flux trap in the ATR*
- *The filter will boost the fast neutron flux and harden the flux spectrum to simulate a fast reactor environment*
- *The INEEL will work with ANL to ensure the FFB meets the needs of the AFCI program*
- *It will be operational in 2005*

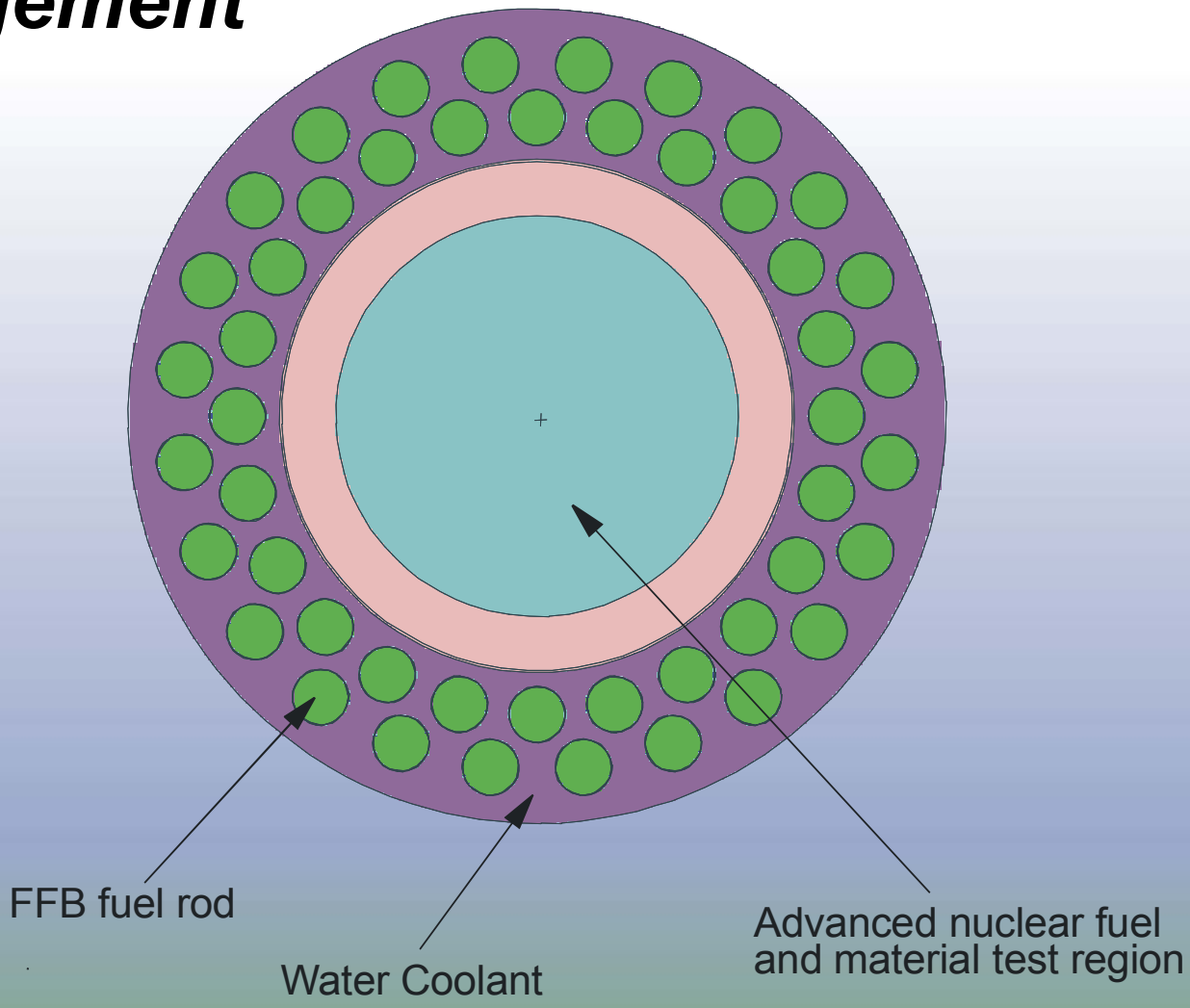
FFB Preliminary Requirements

- *Peak fast neutron flux of 6 to 9 x 10^{14} n/cm^2-s (E>0.1 MeV)*
- *Average fast neutron flux of 5 to 7 x 10^{14} n/cm^2-s*
- *Fast flux to thermal flux (E<0.625 eV) ratio (F/T) of at least 6*
- *Effective test volume of ~1150 cc (OD=4.0 cm, length=91.5 cm)*
- *Equivalent irradiation damage levels of 20-25 dpa/year in a SST specimen*
- *Effective lifetime for the filter fuel of ~280 ATR equivalent full power days*
- *FFB complies with ATR operational constraints and safety criteria*

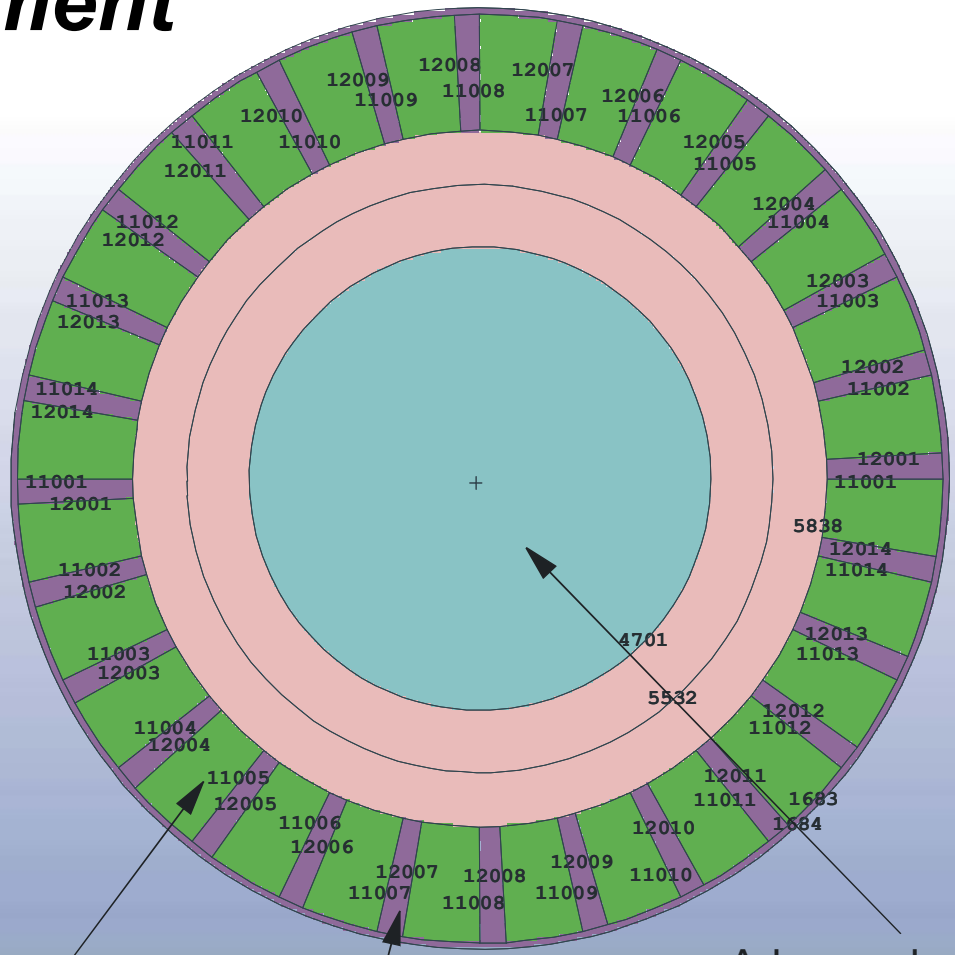
Preconceptual FFB Feasibility Study

- *A preconceptual neutronic feasibility study has been completed, modeling a test capsule containing a transmuter fuel (Pu-12Am-40Zr) in the ATR South flux trap*
  - *With no FFB filter enhancing the fast flux, the peak fast flux is ~3 x 10^{14} n/cm^2-s in the transmuter region*
  - *With an active fuel filter of UO_2 (20 wt% ^{235}U), fast neutron flux in the fuel capsule is 8.3 x 10^{14} n/cm^2-s at the beginning of irradiation (a factor of 2.8 enhancement and a harder spectrum)*
  - *At current operating power levels in the ATR, these preliminary estimates indicate that a peak fast neutron flux greater than the desired minimum of 6 x 10^{14} n/cm^2-s can be achieved*

Radial View of FFB Fuel Rod (UO_2) Arrangement



Radial View of a FFB Fuel Plate (UO_2) Arrangement

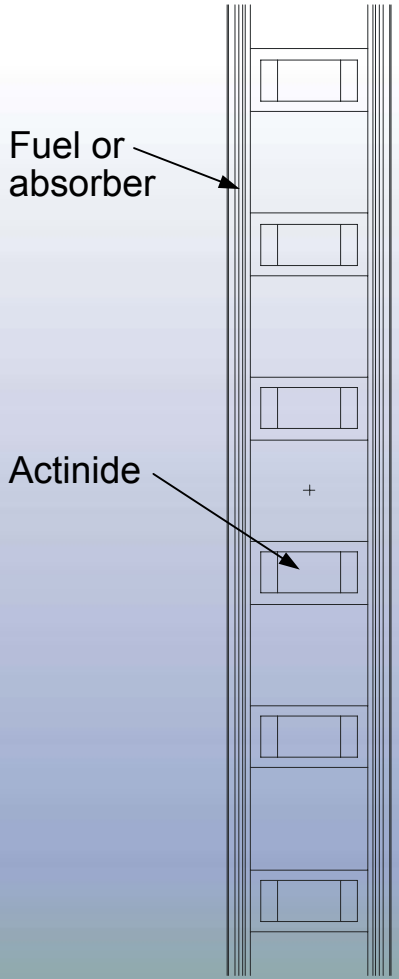


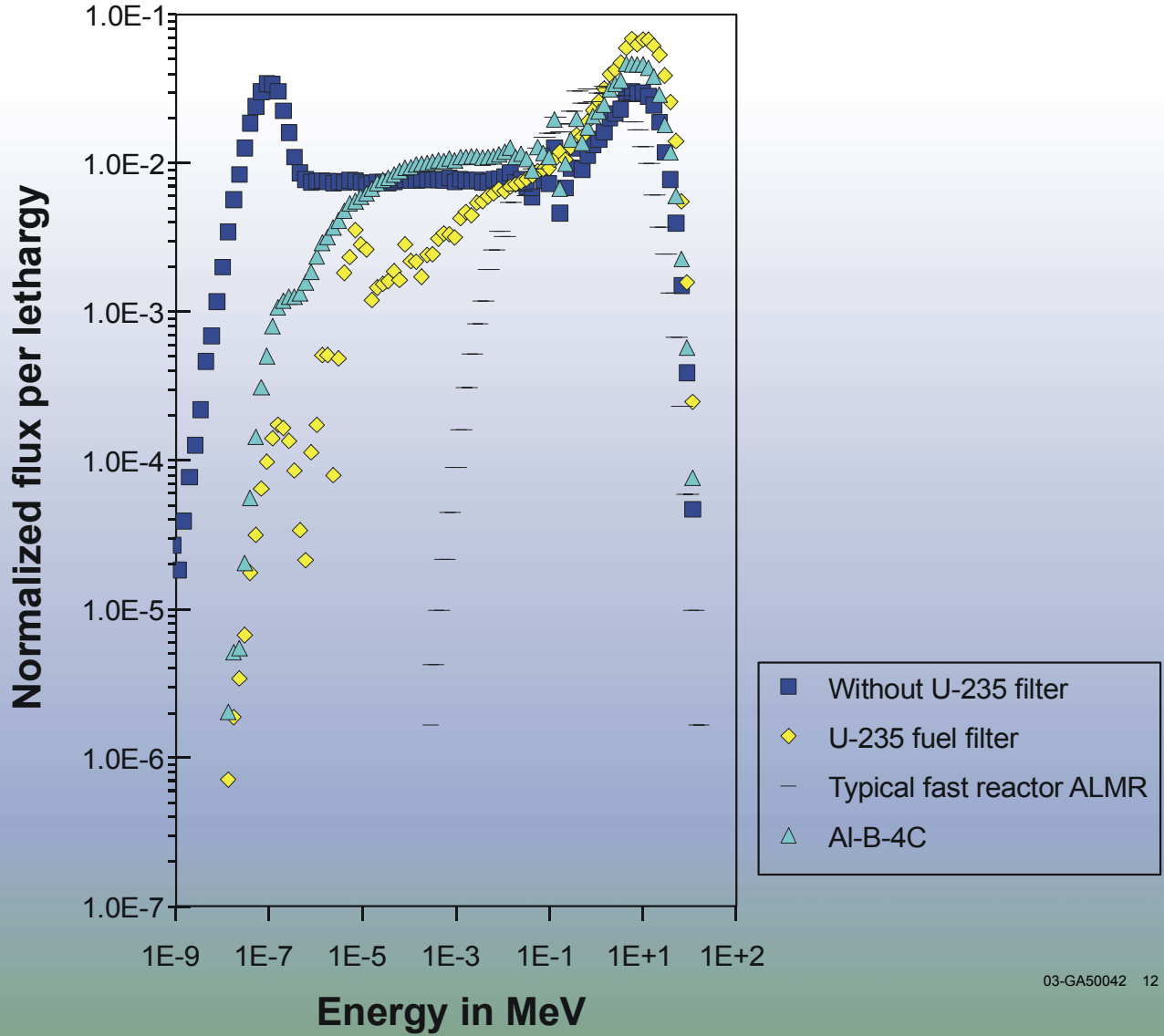
FFB fuel plate

Water coolant

Advanced nuclear fuel and material test region

The UO_2 FFB hardens the Neutron Spectrum





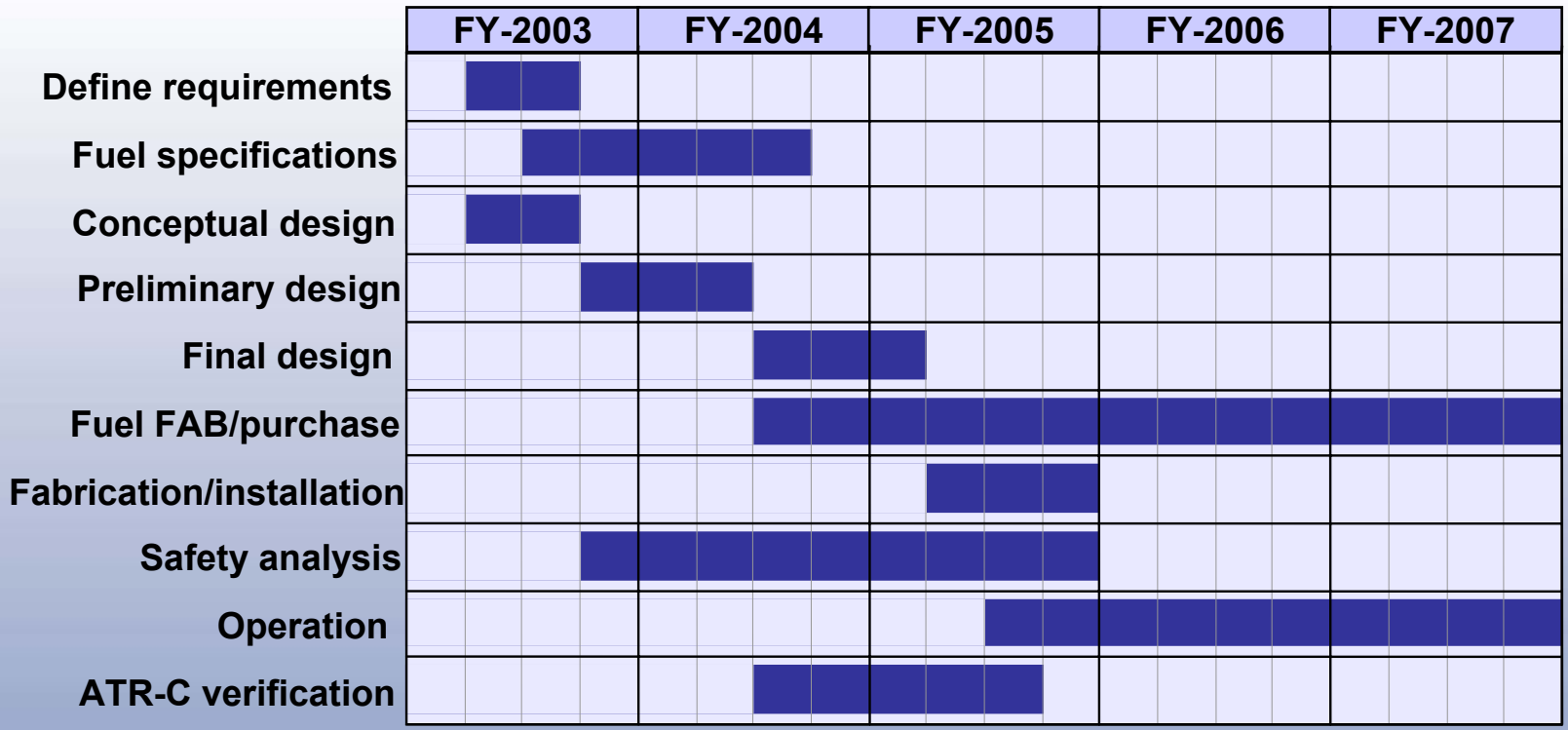
Conceptual Design Analyses are Needed for the FFB

- *Fast flux enhancement will be optimized together with fuel depletion and cooling*
- *An optimal fuel type and enrichment will be determined*
- *An FFB refueling management scheme will be developed*
- *Conceptual design will be based on a combination of physics, thermal hydraulics, safety, and cost analyses*

Safety Analysis

- *The preconceptual analyses indicate the FFB will require a loading of approximately 3 kg ^{235}U (20 wt%)*
- *The impact of the FFB in the south flux trap position will require evaluation*
- *A series of ATRC critical experiments will also be needed to benchmark the analysis and verify the impact of the FFB on the ATR driver fuel plate fission power profiles*
- *The evaluation could result in changes to the ATR safety analysis report*

FFB Schedule (assuming a 1 Jan 03 start)



Analysis Conclusion

- *The analyses show that it is feasible to boost the fast flux in the ATR south flux trap by a factor of 2-3 and produce a fast flux greater than 6 x 10^{14} n/cm^2-s*
- *The boosted flux spectra will be more prototypic of fast reactor spectra*

Summary

- *An FFB is needed to support AFC fuels testing*
- *The INEEL has the capability to design and install an FFB in ATR*
- *A similar FFB was operated successfully in a low-power position in ATR*
- *The INEEL wants to perform this work*
- *The original schedule will slip until funding is received*
- *Detailed planning and requirements definition will start when funding is received*